

## RADIATION HARDNESS OF GaAs p-i-n DIODES TO NEUTRON IRRADIATION

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### ABSTRACT

The performance of Gallium Arsenide p-i-n detectors after neutron irradiation has been studied. The detectors have been irradiated with 1MeV neutrons at various neutron fluences up to approximately  $6 \cdot 10^{14}$  n/cm<sup>2</sup>. Results are presented for the effect on leakage currents and charge collection efficiencies for alpha particles impinging on the front and back contacts, and minimum ionising electrons. The signal from minimum ionising electrons was well separated from the noise even at the highest neutron exposures achieved, therefore the diodes are still operational as detectors. There is evidence for a change in the E-field penetration as a function of bias voltage from alpha particle measurements. Saturation of damage is observed in both the I-V characteristics and charge collection measurements.

### 1. Introduction

The operation of detectors at the LHC is most challenging in terms of radiation damage. Detectors for tracking applications inside the inner cavity of an electromagnetic calorimeter and close to the interaction point will receive charged particle doses in the range of  $\sim 10$  Mrad and fast neutron fluences  $\sim 10^{14}$  n/cm<sup>2</sup> during the lifetime of an experiment<sup>1</sup>. The basic damage mechanisms in semiconductors are conveniently separated into two categories<sup>2,3</sup>: a) Bulk effects, which are manifestations of the displacement of atoms from their normal sites in the crystal lattice. b) Surface effects, which are long-term ionisation effects in the insulators that adjoin the active semiconductor region. In this paper we discuss the effects of bulk damage due to neutron irradiation on the properties of GaAs detectors.

Gallium Arsenide detectors have been shown<sup>4</sup> to be radiation resistant to neutron irradiation for fluences up to  $10^{15}$  n/cm<sup>2</sup> and consequently the use of GaAs detectors as a part of the inner tracker has been proposed by the ATLAS collaboration<sup>1</sup>. For this work pad detectors were irradiated in the ISIS spallation neutron source at the Rutherford Appleton Laboratory<sup>5</sup>. The energy spectrum of the ISIS neutrons is similar to that produced in a hadron collider<sup>6</sup>. The absolute neutron fluence is estimated to be known with an error of 20% and the relative calibration between fluences does not exceed 2%.

### 2. Detectors

The detectors were diffused p<sup>+</sup>-i-n<sup>+</sup> structures fabricated on LEC grown semi-insulating Gallium Arsenide. The n<sup>+</sup> ohmic contact covered the whole backside of the detector whereas the front side was patterned with four circular pads of 3mm in diameter, the p<sup>+</sup> blocking contacts. The thickness of the substrate was 450 $\mu$ m. More detailed description of the contacts can be found elsewhere<sup>7</sup>. Forty eight diodes have been